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The manual is most attractively spaced; and unusually well-illustrated for a laboratory manual. The questions and special reports are varied and interesting. Some of the questions (*e. g.*, on nutrition) seem too difficult; as do one or two of the graphic charts; and ray flowers and petals are confused (p. 31). Some good tables, directions, etc., are included; the clay-pipe charcoal experiment is one of several neat devices.

These books ought to do much to secure sufficient uniformity of treatment of the "syllabus" to enable New York City teachers to estimate its real value. They must also prove a great help to many of the present uncertain interpreters of it and of "nature" and should lead to great improvement in the content and presentation of first-year biology.

JEAN BROADHURST.

OF INTEREST TO TEACHERS*

Professor E. L. Thorndike discusses methods of testing the results of the teaching of science (*School Science and Mathematics*, April). It contains much that is helpful to biology teachers in estimating the results obtained, but only the definite suggestions are quoted here.

"The topic which I am to discuss is one of enormous complexity. The changes in human beings which result from the teaching of science in schools are real, are measurable, and will some day be defined in units of amount as we now define changes in the rate of a moving body or in the density of a gas. But they include thousands of different elements; they vary with every individual; some of them can be demonstrated only long after school is completed; and at present units and scales in which to state changes in knowledge, power, interests, habits and ideals are mostly matters of faith. An adequate measurement of the changes wrought in one class by one course in physics would be a task comparable to a geological survey of a state or an analysis of all the materials in this building."

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Professor Thorndike's suggestions fall "into two divisions according as one searches for means of measuring the specific information, skill, interests, and habits added by courses in science, or the more general changes in total mental make-up—in, for instance, open-mindedness, accuracy, zest for verification and the like.

"The specific changes are, of course, the easier to measure. Indeed, my first suggestion is that we make scientific use of the measurements that we already make. For example, the regular school examinations are, or should be, careful scientific measures of important changes in our pupils. If we would test our classes with the examinations set by other teachers, have the pupils' work graded by other teachers, and print questions, work and grades, we should be making a start toward a real measurement of educational achievement. If examinations are worth giving at all, they are worth giving, at least occasionally, in such a way as to measure not only how well a pupil has satisfied some particular person, but also what he really is or knows or can do in certain special fields. . . . . . .

"We need thousands of significant questions, in each science, thousands of 'originals' in physics, chemistry and biology like the originals of geometry; and above all we need to have thousands of classes tested by outside examiners; for if an examination, instead of being a hasty, subjective selection of questions, graded still more personally (and alas, how hastily), were made a serious educational measurement, the examination papers of a year would alone give us a large start toward knowledge of what science teaching actually does.

"Knowledge may, however, be measured more conveniently than by the examination of notebooks, essays, or replies to questions of the ordinary sort. These have the merit of adequacy and richness, but the defects of measuring too many things at once and too indefinitely. Greater uniformity in the use of the test, quickness in scoring it, and freedom from ambiguity in the numerical value assigned can be secured by the exercise of enough ingenuity. I will mention two tests as samples of the many that are possible. The first is an adaptation of a test, devised by Ebbinghaus to measure mental efficiency in general, in filling in words omitted from a passage. From even the hastily devised sample presented here it will be seen that this form of test is scored with reasonable ease. The speed of an individual in selecting words to fill the gaps and the appropriateness of his selections together measure his knowledge. The former is scored with no effort at all and the latter with far less effort than is required to evaluate answers to questions, essays or experimental work. The paragraphs and omissions therefrom should be arranged with care and improved after trial, but it may be of interest to some of you to compare the ratings obtained in six or eight tests of five minutes each like the following:

"A body changing its position in space moves in a certain ....at a certain .... A..............in the ....called acceleration. To change either the ....or the......................of a moving ....requires...... Suppose a pound of lead to be held at rest 500 feet above the surface of the ocean by a string to be cut. The body will..................toward the and etc.

"The second is a very simple development of so-called association tests which I have used with good success in regular examinations in psychology for a number of years. It needs no explanation other than a sample.

"Write after each of these words some fact which it suggests to you.

acceleration
density
gravity
expansion
current
elastic
lever
inclined"

"This test may be modified by selecting given words much less easily provocative of thoughts about facts of science, and being mixed, if necessary, with words that would call up facts of science only in a person absorbed by scientific interests.' Of course if 'such association tests are to be used to measure interest, they should not be used previously in the form calling definitely for facts about science.' These tests of interest may be used to measure both special interest in particular sciences and general interests, as in fact rather than fiction, knowledge rather than opinion, or verification rather than dispute.

"Of course means of measuring the general changes wrought by the study of science I will mention only two. The first concerns the power to utilize experience well in thought.

"What is needed for this purpose is a series of problems or tasks, relative success with which depends as much as possible upon having power to use experience and as little as possible upon having had certain particular experiences. For example, relative success with the problem, "Which is heavier, a pint of cream or a pint of milk?" is determined largely by ability to select in thought the essential fact that cream rises and to infer its obvious consequence. The data themselves are possessed adequately by all, or nearly all, pupils alike.

"To get such problems we wrote some time ago to one hundred teachers of science, half in universities and colleges, and half in secondary schools. I quote some of them:

"Rain drops are coming straight down. Will a car standing still or one moving rapidly receive in one minute the greater number of drops on its roof and sides?

"Since it is possible, for a person to float in water why is it possible for him to sink?

"A cylinder and a cone equal in base and in altitude rest on a plane surface. Which is harder to tip over?

"A magnet attracts two iron nails. If the magnet is removed will the nails attract each other?

"Does an iron ball weigh more when it is hot than when it is cold?

"If a bottle of gas which is lighter than air be placed with its open mouth upward, will the gas escape from the bottle or will the heavier air press the gas back into the bottle?

"Will a ship that will just barely float in the ocean, float on Lake Erie?

"Will a pound of popcorn gain or lose weight or stay the same after it has been popped?

"The second means of measuring changes in general power to think is an adaptation of one devised by Professor R. S. Woodworth, in which the pupil picks out from such a series as that below, the statements that are logically absurd, not possibly true. It will be seen that statements could be chosen which would test the power of analysis and of thinking things together in any field of science from the most specialized to the most universal. Following is an example of this form of test.

"Put a mark in the margin opposite each of the following sentences which is absurd:

"Though armed only with his little dagger, he brought down his assailant with a single shot.

"Silently the assembly listened to the orator addressing them.

"While walking backwards he struck his forehead against a wall and was insensible.

"I saw his boat cleaving the water like a swan.

"With his sword he pierced his adversary, who fell dead.

"The storm which began yesterday morning has continued without intermission for three days.

"That day we saw several ice-bergs which had been entirely melted by the warmth of the Gulf Stream.

"Our horse grew so tired that finally we were compelled to walk up all the hills.

"Many a sailor has returned from a long voyage to find his home deserted and his wife a widow.

"The two towns were separated only by a narrow stream which was frozen over all winter.

"The great advantage of these means of measuring intellectual ability lies in their rapidity and objectivity. If well devised, only two answers are possible, the pupil is measured easily, rapidly, and independently of subjective factors, and his condition is defined in terms of a simple numerical value.

"There is no time for me to discuss methods of making, recording and utilizing these or the hundreds of other equally worthy measurements of educational achievement, that is, of changes produced or prevented in human nature. Nor is this a proper occasion to outline the precautions that are required by the complexity and variability of facts of intellect and character and the absence of well-defined scales with equal units and known zero points, in which to measure facts of intellect and character. For our present purpose it is enough to know that, in spite of difficulties, the measurements can be made, and that a man of science can, if he will, be as scientific in thinking about human beings and their control by education, as in thinking about any fact of nature."

THE BEST METHODS OF TEACHING BOTANY TO SCHOOL STUDENTS*

It would seem that the title of the present address should read The Method of Teaching Botany, since I should argue that there is only one method deserving mention, namely the experimental. Perhaps I should say that I do not underestimate the value of purely observational processes; but unless these lead up to some sort of experimental trial or test it would seem that such method is inadequate in scientific education. Students of agriculture are concerned chiefly with the behavior of plants rather than with the form of plants. One can scarcely imagine circumstances under which a farmer would find it necessary to describe in technical language the form of a leaf or the structure of a flower. The important thing for him is to know what the functions of the various parts are and how they behave. If he knows this, he may then go further if he will. The inference from this is that our education should aim at cultivating the habit of mind which looks for the exact behavior of plants and is able to sift out the causes of variation in behavior. In the brief time at my disposal, I can do no more than to point out some fundamental ideas underlying the successful application of the method of experimentation.

In the first place, the proper attitude of mind in the teacher is most essential. He must have constantly before his mind the fact that plants are living organisms. To be sure they do not move as do animals and we therefore are sometimes slow to regard them as being as much alive as animals are; and one of the practical difficulties in education is to get our pupils to realize this. If plants are living, then the idea of change constitutes

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* From an article by Professor F. E. Lloyd in a report on Agricultural and Industrial Education, Department of Agriculture, Montgomery, Alabama.